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13. ABSTRACT *(Maximum 200 words)*

In this report, a series of studies concerning the use of neuronal map data structures for the solution of perceptual, attentional and pattern classification problems have been developed. Models for visual attention, based on the representation of an attentional space as a two dimensional map have led to a model of visual attention which has been successfully used in the application of a space-variant active vision system, described below. It has been demonstrated that stereo fusion limits, such as Panum's fusional area, scale in a manner which is determined by the size of a cortical hypercolumn, and the local value of cortical magnification factor, supporting a model in which stereo disparity is computed by a local correlational operator defined on the span of a single pair of ocular dominance columns. Methods for numerically modeling conformal topographic cortical maps have led to important insights into the pattern level description of these cortical systems. A prototype space-variant active vision system has been constructed, with funds for hardware support from DARPA, and a number of difficult algorithmic problems in motor control, attention, space-variant image processing, and space-variant pattern classification, have begun to studied. One book has been published in this project period: Computational Neuroscience, Eric Schwartz, MIT Press (1990) which presented the proceedings of an earlier conference which introduced the term "Computational Neuroscience" into its current widespread use.

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SUMMARY

In this report, a series of studies concerning the use of neuronal map data structures for the solution of perceptual, attentional and pattern classification problems have been developed. A multiple map model for pattern classification [1] shows that the use of two dimensional representation, for an arbitrary high dimensional problem in pattern recognition, leads to an efficient approach to pattern classification, and provides insight into the wide-spread use of two dimensional map representation in the cortex. In other applications, models for visual attention, based on the representation of an attentional space as a two dimensional map [2, 3] have led to a model of visual attention which has been successfully used in the application of a space-variant active vision system, described below. Also, it has been demonstrated that stereo fusion limits, such as Panum's fusional area, scale in a manner which is determined by the size of a cortical hypercolumn, and the local value of cortical magnification factor [4]. This in turn supports the notion that stereo disparity is computed by a local correlational operator defined on the span of a single pair of ocular dominance columns [5].

Methods for numerically modeling conformal topographic cortical maps [6] and for modeling the structure of columnar maps, such as the ocular dominance column and orientation column systems [7] and [8] have led to important insights into the pattern level description of these cortical systems. The conformal topographic model of primate V-1 has been confirmed experimentally by 2-deoxyglucose mapping and computer brain flattening [9], and this model has been used to provide guidelines for the construction of VLSI space-variant sensing systems [10, 11].

As one consequence of this modeling effort, it appears that both of the major column systems of primate visual cortex are instances of band-pass filtered white noise, and that most existing (complex) models for the description of these systems are based on a filter, often hidden in the depths of other modeling mechanisms which are not essential to the production of the observed columnar patterns. In the case of the orientation column system, there are additional topological complexities to the band-pass filtered noise which suggest that the hypercolumn pattern of V-1 is a form of topological singularity whose structure is an unavoidable consequence of the representation of orientation in a two dimensional cortical surface [8, 12]. Finally, a generalized image warp technique has been developed, which we term the "protocolumn algorithm", which provides image level models of the mapping of ocular dominance and orientation column systems at the level at the level of primary visual cortex[13]

Finally, many of the ideas developed in this project period, and in two prior periods of AFOSR support, have reached fruition in the construction of a space-variant active vision system. The use of an image sensing architecture, such as the complex log or conformal structure shown in our work to provide an accurate model for primate vision, has begun to have an important influence on robot vision systems. An initial prototype system has been constructed under hardware support from DARPA, and a number of difficult algorithmic problems in motor control, attention, space-variant image processing, and space-variant pattern classification, have begun to studied [14, 15, 16, 17, 18].

One book has published in this project period: Computational Neuroscience, Eric Schwartz, MIT Press (1990) which presented the proceedings of an earlier conference which introduced the term "Computational Neuroscience" into its current widespread use.

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